TECHNICAL REPORT

69-78-PR

EVALUATION OF ARMY AIRCREW PROTECTIVE ARMOR IN VIETNAM

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June 1969

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

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FOREWORD

This report is the third* in a series concerned with the Human Factors implications of body armor for U. S. Army aircrewmen. The intent of this series is to assist the designer of body armor by specifying design criteria, human factors evaluation methods and test results. The research described in this report evaluates torso protective armor for helicopter pilots and torso and seat protective armor for crew chiefs and door gunners. The cooperation of aviation unit and aircraft commanders made it possible for the protective items to be used and rated by aircrewmen operating in the combat theater.

*Previous reports are:

Technical Report 67-28-PR: Human Factors Requirements for the Design of Helicopter Aircrewman's Seat and Groin Protective Units, Sep 66, AD 640 891.

Technical Report 68-4-PR: Human Factors Evaluation of Body Supported Aircrewman's Buttocks and Crotch Protective Units, Jul 67, AD 658 034.

TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

Thirty five U. S. Army helicopter crew members evaluated the design features and acceptability of .30 caliber armor-piercing protective armor on practice or actual live-fire aerial missions in South Vietnam. Twenty pilots used Torso Front Protective Armor, and 15 crew chiefs and door gunners used Torso Front Protective Armor, Torso Back Protective Armor and Seat/Groin Protective Units. They rated the following variables: fit, comfort, interference with movement, suitability of outline and contour, acceptability of armor before and after experience with the latest itsms, desirability of particular items on particular missions and body areas requiring protection. In general, they evaluated the itsms as both desirable and acceptable and expressed a strong desire to wear body armor on a wide variety of flight missions. Responses indicated that the Torso Front Protective Armor requires only minor improvement, but the Torso Back Protective Armor requires changes in both outline and contour. The Seat/Groin Protective Unit requires improvement to help it swivel with the user.

INTRODUCTION

Background

Helicopter aircraft are being exposed to increasingly higher levels of ground fire from enemy forces in the Republic of Vietnam (RVN). Their effectiveness and vulnerability during hover, landing and take-off make them prime targets for ground fire.

Hit-and-run tactics of the enemy in RVN thus far have precluded their use of large numbers of shrapnel-producing anti-aircraft weapons. Their maneuvering units have relied on direct-fire weapons of .30 caliber or less (small arms) as their principal defense against U. S. helicopters, although .50 caliber weapons are occasionally used defensively and mortars are often used offensively against helicopters.

The protection afforded helicopter crew members by very efficient shrapnel-protective armored vests (flak vests) has been reduced because high-velocity, stable and very dense armor piercing small arms projectiles penetrate them with ease. To counter this threat, the U. S. Army Natick Laboratories (NLABS) developed body armor units for aircrewmen of UH-1 series aircraft which would stop .30 caliber armor-piercing projectiles at 100 meters range. Because prior research had produced both the rigid armor materials with this capability and the necessary design parameters to provide a large measure of protection with a tolerable degree of restriction, prototypes were quickly made and sent to RVN for use. Two principal problems were encountered: (1) difficulty in fabricating the armor materials to the desired shape and contour while retaining penetration resistance, and (2) difficulty in providing maximum coverage with minimum weight and performance decrement. The first problem was solved fairly rapidly. The earliest protective armored components for the crewmen were mosaics of small flat sections of armor material fastened to an appropriately contoured backing. These soon were superseded by mosaics of fewer and larger plates which were curved to a constant radius. Additional advances permitted curving the armor materials to a variable radius in one dimension and forming the entire armor component in one piece to eliminate structural weakness at the joints. It has now become possible to form a single piece of armor to almost any desired contour in any dimension.

The rapid advances in the technology of armor fabrication have resulted in constant revision of prototype protective armor systems, with shape and contour more closely approximating that of the human body. Results are reduced weight, bulk and restriction, with retention of maximum protection.

Limitations in available human factors capability, the small number of UH-1 helicopters and crews available for personnel armor evaluations and the

urgent need of prototype armor items for combat all combined to restrict human factors evaluations of prototype protective units, which did not keep pace with design improvements made possible by advances in fabrication technology.

In 1966, the Army Materiel Command formed an investigating team and sent it to RVN to determine what armor was available and being utilized in the combat zone, and to establish further requirements for both personnel and aircraft armor.* The NLABS representative (co-author E. R. B.), in addition to his team activities, cooperated with human factors personnel in planning and conducting a limited evaluation of the newest prototype aircrew protective armor being used in Vietnam. Plans were made to study torso, seat and leg armor for crew chiefs and door gunners and torso armor for pilots and copilots.

Objectives

The principal objectives of the evaluation of the specified aircrew protection were: to determine the adequacy of each available body armor item with regard to fit, comfort and lack of restriction to movement and to determine what changes in dimension or contour were needed to better accommodate the aviator population. Secondary objectives were to evaluate the acceptability of body armor to flight crews before and after experience with the latest items, to determine which items of body armor would be worn on a particular type of mission by men in the different crew positions, and to discover the best-liked features of each item which should be retained in future designs.

GENERAL METHODOLOGY

Approach

Objective performance data were not collected because of the time and facilities which would have been required to train an observer from each aviation unit and to have each crew fly its mission twice, once under an experimental and once under a control condition. Instead, data were collected on each crew member's subjective impression of the fit, comfort and restriction imposed by each armor item. This required only one flight by each crew to investigate the following variables: the nature and severity of any interference with job performance, the location and degree

*See description of activities and findings in "AMC Armor Team: Report of visit to South Vietnam - 14 February to 4 April 1966", Headquarters U. S. Army Materiel Command, Washington, D. C. 20315, April 1966.

of any restriction to movement, the adequacy of the item's principle dimensions, an estimate of the length of time the item could be used without performance decrement, speed and ease of donning and doffing, general comments or suggestions for improvement, the best-liked features of the item, changes occurring during the study in aircrew members' attitudes toward the use of protective armor, and their preferences among protective items for use on missions of different types.

Questionnaires

In order to implement this approach the following six Aircrew Body Armor Design Evaluation questionnaires were developed, tried out on four Army Aviators, revised and condensed to the final form as shown in the Appendix:

1. Background Information Questionnaire
2. Individual Item Questionnaire
   A. Torso Front Armor
   B. Torso Back Armor (always worn with Torso Front Armor)
   C. Leg Protector
   D. Seat Protector
3. Final Questionnaire

Administrative Procedures

The administration of the evaluation in RVN was made as simple and rapid as possible. All the participating flight crews at a particular location were briefed as a group. Each crewman then completed the Background Information Questionnaire individually. Following this, the experimenter measured the members of a complete crew, fitted them with the experimental protective armor items and accompanied them on a live-fire aerial mission (practice or actual) to insure proper use of the tested items and answer any questions. After completing their mission, the crew members filled out individual item questionnaires and the Final Questionnaire, and were debriefed by the experimenter.

The procedures used had a number of advantages. They permitted rapid and easy collection of data from a crew sample of adequate size and crew members were encouraged to express freely their individual comments concerning the protective items. Moreover, communication and

understanding were encouraged by the immediate availability of the experimenter to answer questions raised by field personnel concerning the tested items. In addition, as each flight crew participated as a unit, it retained its operational capability and a crew performing an evaluation under simulated mission conditions could immediately be diverted to an operational mission if required. Finally, the minimal time required for aircrew participation helped to insure the vital cooperation of commanders and crews.

Crew chiefs and door gunners were to have evaluated a prototype hinged leg protector which was designed to accommodate varying leg lengths.* However, adjustment of the length between subjects was found to require more time than could be afforded in the field situation so the leg protector was not evaluated.

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* This leg Armor (full thigh and lower leg, articulated) consisted of a convex shaped unit intended to cover the outer surface of the thigh, and a convex shaped unit which covered the outer surface of the lower leg extending approximately 3" above the knee cap to approximately 3" above the ankle area. The thigh and lower leg unit were mechanically joined together with a metal hinge unit, so that the thigh and leg unit would pivot with thigh and leg movement. The armor material consisted of Dual Hardness roll bonded steel, having an areal density of 12 lbs. per square foot, designed to provide protection against 30 caliber AP projectiles. Extending from each side of the lower leg armor were steel foot support paddle shaped units which were attached to the lower leg armor by 4 bolts and nuts. In order to allow some size adjustment 4 sets of spaced holes were provided in the upper area of the paddle unit. By proper adjustment, the weight of the leg armor would rest on the edges of the paddle and on the floor of the aircraft relieving weight on the thigh when in a seated position. Nylon pile and loop straps were attached to the thigh and lower leg unit in order to provide adjustment and retain the armor on the leg. An adjustable cushion ankle shoe adjustment strap was provided in the foot support paddle bracket, designed to hold the armor in place by positioning it on to the leather combat boot. A pair of leg armor weighed 30 lbs. An experimental stock number FSN 8470-NTK-6531 was assigned to identify the item. The item was manufactured by Aeronutronic Division of Philco Corporation, Ford Motor Company under contract #DA-19-129-AMC-736N. (See Figure 1).

Fig. 1. Experimental Aircrew Gunner/Crewchief Full Thigh and Lower Leg Armor, Dual Hardness Steel

Data Analysis

All responses to questionnaire items were tabulated separately for the group composed of pilots and copilots (called "pilots") and for the group composed of crew chiefs and gunners (called "crewmen"). For brevity in reporting, comments from each group were listed verbatim, then essentially identical comments were grouped together and rephrased.

Restrictions to body movement reported by crew members were divided into two categories: major and minor. For a pilot, major restriction was presumed to have occurred if he reported difficulty in performing any movement associated with controlling the aircraft or operating the weapons system. For a crewman, major restriction was presumed if he reported any interference with operating his machine-gun or performing any action important to proper operation of aircraft. Minor restriction was presumed to have occurred if any crew member reported interference with activities not critical to the performance of his major duties, such as reaching for maps or shifting body position for comfort. No restriction was presumed only if a crew member reported that his job performance was essentially unimpaired.

Description of Personnel Evaluating Aircrew Armor

The main sample consisted of 20 helicopter pilots and copilots, jointly referred to as "pilots", and 15 crew chiefs and door gunners, jointly referred to as "crewmen". The aircrews studied were believed to be representative of typical Army aircraft crews engaged in combat flights in South Vietnam. If this assumption is correct, the results based on these samples would be unbiased with respect to the total population of such aircrews. Practical considerations in a combat situation limited the size of the samples. The relatively small size of the sample as compared with the total population means that any sample of such size might differ considerably from other samples similarly selected. However, the results should be useful first approximations, and far superior to no information, or to biased opinions of individuals (samples of 1).

Pilots. The ages and body dimensions of the pilots are summarized in Table I. They ranged in rank from Warrant Officer (W-1) to Colonel, and in length of service from 3 to 27 years. Four were college graduates, 13 had some college training, and three had completed high school. They had from 1 to 23 years of flying experience, from 240 to 8,000 flying hours, had been in the Vietnam combat zone from 1 to 16 months and had been in combat a total of from one to 60 months. They had flown from 1 1/2 to 100 combat hours and from 2 to 1000 combat missions. Of the 20, 16 had received battle

stars or the Air Medal (many having received additional clusters for the Air Medal) and at least a quarter had received the Silver Star, the D. F. C., the Soldier's Medal, or the Bronze Star. Seventeen had previously worn either the "flak vest", the flat "chest protector" or both in combat and one had used "groin armor".

Table I: Summary statistics for age and body dimensions of pilots who evaluated the torso front protective unit.

Dimension	Range	Mean	S.D.	N
Age (years)	26-47	34.2	7.1	20
Weight (pounds)	140-200	175.5	17.4	20
Height (inches)	65-75	70.4	2.7	20
Chest Circumference (inches)	36-44	39.5	2.3	15

Crewmen. The ages and body dimensions of the "crewmen" are summarized in Table II. In general they were younger, smaller, and less experienced than the pilots. These men ranged in rank from PFC (E-3) to MSG (E-7) and in length of service from 8 months to 18 years. One of the crewmen had completed college, two had some college, eleven had completed high school, and one had some high school training. They had from 3 months to 12 years of flying experience, from 11 to 4000 flying hours, had been in the Vietnam combat zone from 3 to 12 months, and had been in combat a total of from 3 to 36 months. They had flown from 30 to 300 combat hours and from 25 to 350 combat missions. Six members of the group of 15 had received a total of 4 Air Medals and 3 Combat Infantryman's Badges. Of the 15 crewmen, 12 had previously worn armor, either the "flak vest" (11), the "chest protector" (7), the "groin protector" (1), or a combination of these, while three had never worn any armor.

Table II: Summary statistics for age and body dimensions of crew chiefs and gunners who evaluated the torso front and back protective units.

Dimension	Range	Mean	S.D.	N
Age (years)	19-39	26.2	6.3	15
Weight (pounds)	120-190	160.5	17.6	15
Height (inches)	64-72	69.5	2.4	15
Chest Circumference (inches)	32-40	36.6	2.3	14

STUDY I: ASSESSMENT OF PRE-TEST ATTITUDES TOWARD AIRCREW ARMOR PROTECTION

Procedure

Prior to evaluating the protective items during flights, each individual in the main sample completed the Background Information Questionnaire. In doing so, he recorded data describing his background, including flight and combat experience and his previous use of armor. Also, he recorded his attitudes toward wearing armor on combat flights, toward the need for protection of various body areas, and toward present body armor and its use in combat.

Results

Acceptability of Armor in use Before Test.

Results of item 30 of the Background Information Questionnaire indicated that the armor which was in use in Vietnam at the beginning of the study did not satisfy its aircrew users. Responses are shown in Table III. None of the pilots and crew chiefs checked the most favorable answer, "a. It does a good job just as it is." Although 41% checked "b. It is good enough some improvements are needed.", the median (most typical) response was "c. It is fair", and about one quarter checked "d. It is poor", or "e. One would be safer without armor."

Table III: Attitudes toward presently used body armor

30. What do you think of the body armor which is presently in use?		Pilots	Crewmen	Total
a.	It does a good job just as it is.	0	0	0
b.	It is good enough although some improvements are needed.	6	8½*	14½
c.	It is fair.	7½	3	10½
d.	It is poor.	4½	2½	7
e.	One would be safer without armor.	1	0	1
f.	I have no opinion.	1	1	2
		20	15	35

*In this and subsequent tables, a value of ½ means that when two different answers were checked by an individual, each was credited with a value of ½.

Desirability of Armor on Combat Flights

The responses to Question 28 of the Background Information Questionnaire, "In general, how do you feel about wearing body armor on combat flights?" indicated a strong general desire for armor protection. Of 20 pilots and 15 crewmen, 13 pilots and 7 crewmen answered: "a. I like the protection and always want to wear the best armor available." Four pilots and 6 crewmen checked "b. Body armor protection is desirable even though it is heavy, gets in the way and makes it hard to do your job." One pilot checked both answer "a.and answer "b. Only two pilots and two crewmen checked "c. The advantages and disadvantages of wearing body armor are about equal".

Body Areas Requiring Protection

Answers to Item 29 of the same Questionnsire, "What body areas do you want protected most?" differed somewhat between the pilots and crewmen. Table IV gives the rank orders for the two groups.

Table IV: Body areas requiring protection

Rank	Pilots	Crewmen
1 (Most important)	Head & Neck	Chest
2	Chest	Groin (crotch)
3	Abdomen (belly)	Head & neck*
4	Groin (crotch)	Abdomen (belly)*
5	Upper legs	Upper legs
6 (Least important)	Lower legs	Lower legs

*Tied for ranks 3 and 4

Although the responses to the attitudinal items of Study 1 are of intrinsic interest, primarily they were intended to provide a baseline from which changes in attitudes resulting from using the latest protective items could be measured in Study IV. For this reason no additional conclusions will be stated at this time. Study IV will compare attitudes before and after use of the new protective items, and the comparisons will be followed by additional discussion and conclusions.

STUDY II: EVALUATION OF TORSO PROTECTIVE ARMOR

Description of Items

The Torso Front Protective Armor (TFPA) consistsd of a vest-like fabric carrisr and a plate of armor which was contoured to the surface of the torso (shown in Figure 2). The plate extended vertically from tne base of the throat to the waistline and horizontally across the front and sides of the abdomen and across the chest from armpit to armpit. The side-opening carrier of cotton poplin consisted of a back panel, two shoulder straps and a front pocket to contain the armor. The carrier was closed around the body by means of two elasticized waist straps with nylon hook-and-pile closures. The weight of the armor was supported by two shoulder pads integral with the shoulder straps. One of the shoulder straps was equipped with a quick-release, snap-fastening system.

The Torso Back Protective Armor (TBPA) consisted of a contoured back plate in a cotton poplin cover (shown in Figure 3). The TBPA could not be used without the front protective armor as the TBPA fitted in a short pocket attached to the back panel of the TFPA.*

Concept of Use

The torso protective armor was designed to protect the front of the torso for both pilots and crewmen, with the capability of providing optional protection to the back of the torso for those crewmen requiring it. Pilots and copilots sitting in fully armored seats (seat pan, back and rear sides) needed only front protection, but crewchiefs and door gunners sitting in unarmored jump seats required both front and back protection.

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*The full nomenclature for the TFPA is Armor, Body, Aircrew, Small Arms Protective, Front, with Carrier, FSN 8470-NTK-6501, 2 & 3 (Short, Regular & Long). The combination of TFPA and TBPA is termed Armor, Body, Aircrew, Small Arms Protective, Front and Back, with Carrier, FSN 8470-NTK-6571, 2 & 3 (Short, Regular & Long). The carriers were fabricated in accordance with Military Specification, MIL-C-43544GL, Carrier, Body Armor, Aircrewman, Small Arms Protective. The armor plates were fabricated in accordance with Limited Procurement Purchase Description, LP/P DES 48-66 with cited drawing numbers 8-2-217, Aircrew Curved Torso Armor, Front and 8-2-218, Aircrew Curved Torso Armor, Back.

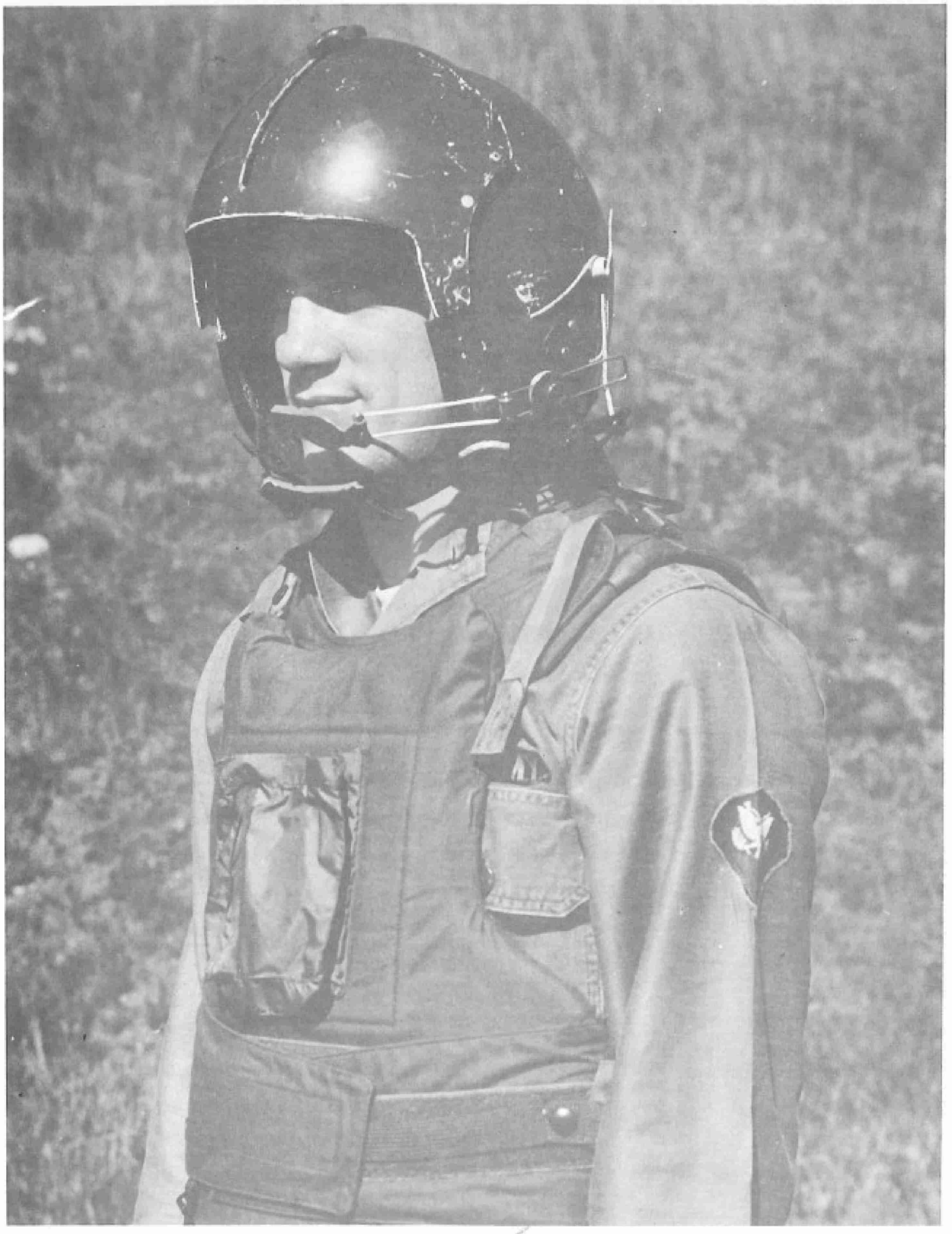

Fig. 2. Experimental Aircrew Torso Front Protective Armor, (TFPA) Consisting of Armor Plate Inserted in Fabric Carrier.

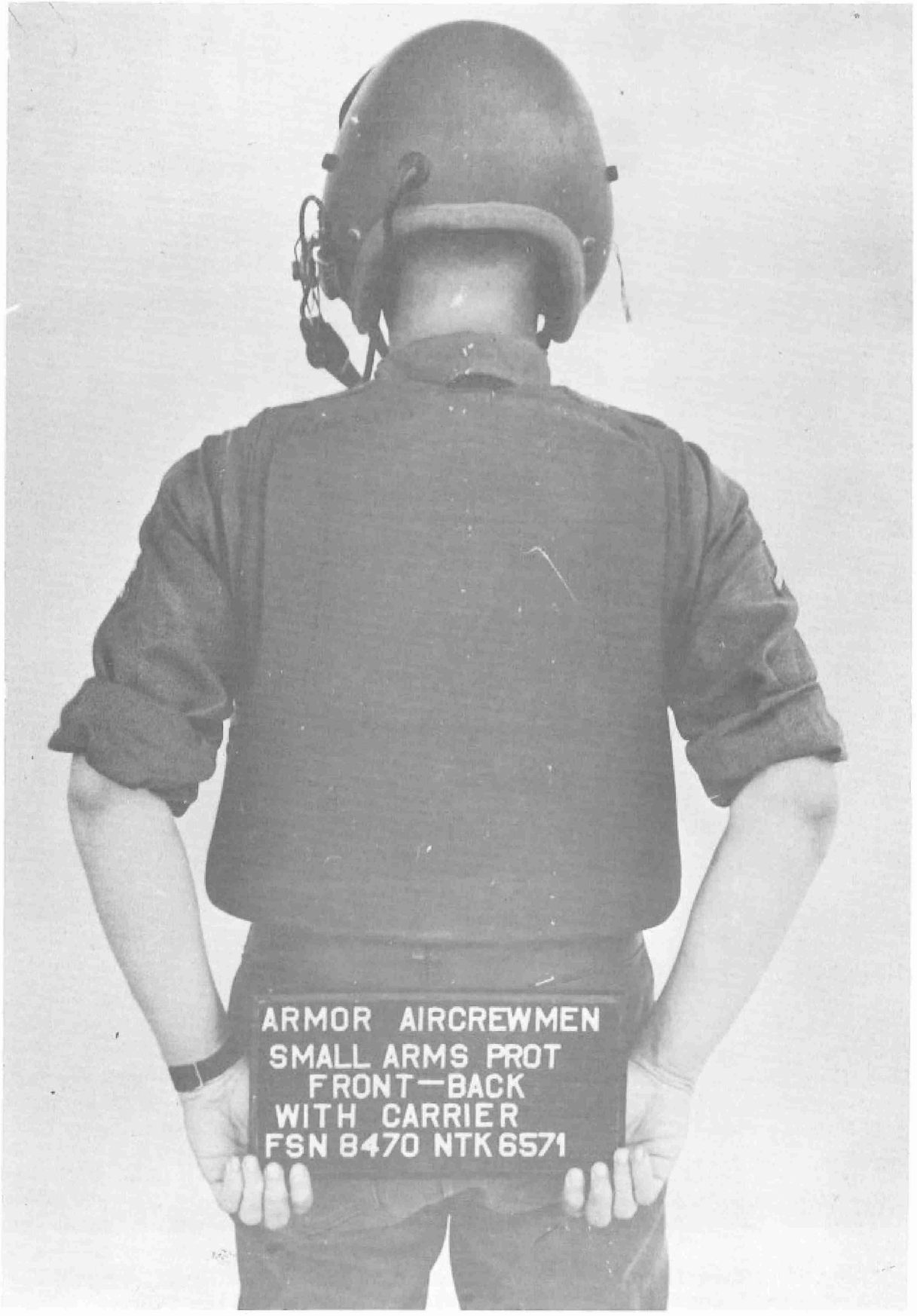

Fig. 3. Torso Back Protective Armor

Although the torso protective armor was intended to be carefully donned and doffed outside the aircraft, a quick release shoulder strap allowed its rapid removal within the aircraft, if necessary. Maximum protection and minimum interference to bending, sitting or stooping required that the front and back armored components be worn as high on the torso as possible. A continuous self-locking, pull-type vertical adjustment on the TFPA and snap-type incremental adjustments on the TBPA provided this capability. Progressive deformation of the shoulder pads was observed just prior to the evaluation. This deformation caused the armored components to be positioned much lower than originally intended, even when adjusted as high as possible. The evaluation was conducted as scheduled with this deficiency unremedied. Interpretation of the obtained results requires consideration of the effects of this malpositioning of the armored components.

Sizing

Both the TFPA and TBPA were provided in three lengths for tall, medium height and short men. The horizontal dimensions were sized to accommodate the narrow-chested and large-waisted men in each height category. This was done to provide a minimum of restriction to arm and shoulder movements of narrow chested men (at the expense of some protection) and a maximum of protection to the abdominal region of large waisted men (at the price of some weight and bulk). Table V shows the body size ranges of the intended wearer and the principal dimensions for each size of TFPA and TBPA. A given individual would normally (but not necessarily) wear the same size TBPA as TFPA.

Fitting

Unforeseen baggage handling difficulties required that only two TFPA and one TBPA of each size could be transported to most installations for evaluation. As each helicopter normally carried a crew of four (pilot, co-pilot, crew chief and door gunner), at times several crew members required the same size torso armor. Some crew members were permitted to evaluate armor that was one size too large or too small, in order to obtain maximum utilization of the helicopter crews. Table VI shows that 16 of the 20 pilots were properly fitted while four were not: two tall men and one short man wore size Regular armor while one medium man wore size Short. Seven of the 15 crewmen were properly fitted while eight were not: four tall men and one short man wore size Regular armor, two medium men wore size Short and one medium man wore size Long. Fewer pilots than crewmen were improperly fitted; pilots were fitted first because of the critical need for control of the aircraft.

Table V: Body size ranges of intended wearer and dimensions of each size of Torso Protective Armor.

Body size ranges of intended wearer[1]				Dimensions of torso armor			
Size of torso armor	Stature	Chest circumference	Waist circumference	Type of torso armor	Weight (pounds)	Vertical height[2] (inches)	Width across upper torso[3] (inches)	Width across lower torso[4] (inches)
Short	63.5-66.9	30.5 - 40.0	24.0 - 36.5	TFPA[5]	12.6	13	9-3/8	14-3/8
				TBPA[6]	12.4	14-3/4	10-3/4	13-7/8
Regular	67.0-70.4	31.0 - 42.5	24.0 - 36.5	TFPA	13.4	14	9-1/2	14-3/8
				TBPA	14.2	16-5/8	12	15-5/8
Long	70.5-75.0	34.0 - 44.0	25.0 - 38.0	TFPA	16.6	14-7/8	10-5/8	16-1/4
				TBPA	18.4	18-3/8	13-1/4	17-1/2

Notes:
1. Unclothed anthropometric measurements
2. For TFPA and TBPA, measured from base of neck to waistline
3. For TFPA, measured across chest at armpit level; for TBPA, measured across back at shoulder level
4. For TFPA and TBPA, measured across abdomen at waist level
5. TFPA = Torso Front Protective Armor
6. TBPA = Torso Back Protective Armor

Table VI: Number of men evaluating each size of torso armor who were properly and improperly fitted.

	Pilots (Front Only)		Crewman (Front and Back)	
Size of Armor	Properly Fitted	Improperly Fitted	Properly Fitted	Improperly Fitted
Long	7	0	0	1
Regular	8	3	6	5
Short	1	1	1	2
Total	16	4	7	8

Results

Restriction to Movement.

Properly fitted crew members. No major restrictions and only three minor restrictions were reported by pilots and crewmen properly fitted with torso armor. One pilot could not reach from the right hand seat to the center console with his right arm without leaning to the left. Another pilot rubbed his right elbow against the lower part of the TFPA while making extreme body movements prior to take-off. One crewman had some difficulty in bending to the sides.

Improperly fitted crew members. None of the four pilots who were misfitted reported either major or minor restriction and three of the seven crewmen who were misfitted reported restriction. One crewman reported interference with controlling his machine gun on the right side of the aircraft, while another reported being unable to bend far enough at the waist to perform his duties. Both of these restrictions were considered major. The minor restriction was to a crewman who could not move cargo easily because of interference with his arm movements.

Adequacy of Dimensions.

Pilots. As is shown in Table VII the 16 properly fitted pilots considered the dimensions of the TFPA to be generally adequate or too small, as was the intent of the design. The lack of complaint concerning curvature of the armor indicates that it was a reasonable compromise for the diverse body sizes encountered. The one complaint of "too long" for

the length of the size Long TFPA and two complaints of too wide for waist width indicate a possible need to reduce these dimensions slightly prior to large-scale testing. The four improperly fitted pilots unanimously rated the length, chest width, waist width and curvature as "about right". The average estimate from all pilots of the length of time the TFPA could be worn continuously was 4.6 hours (S.D. = 1.8 hours), which appears entirely adequate.

Crewmen. As shown in Table VIII the properly fitted crewmen rated the front waist width and chest curvature of the TFPA and the shoulder width of the TBPA as "about right". Three crewmen did not rate the TFPA. The complaints concerning the length and chest width of the TFPA and length, back waist width and back curvature of the TBPA indicate the possible need to alter these dimensions. The eight misfitted crewmen reported in a similar pattern: the six misfitted with armor too short for them reported length, front waist width and chest curvature of the TFPA and length, shoulder width and back curvature of the TBPA to be "all right". The TFPA chest width received one complaint of "too narrow" and one of "too wide" and the TBPA back waist width received one complaint of "too narrow". The two crewmen misfitted with armor too long for them did not rate the TFPA, one rated the back length of the size Long TBPA as "too long" and one rated the shoulder width of the size Regular TBPA as "too narrow". The average estimate from all 15 crewmen of the length of time the TFPA and TBPA could be worn continuously was 3.3 hours (S.D. = 1.9 hours), which, although less than the pilots' estimate, appears adequate.

Speed and Ease of Donning and Doffing Torso Protective Armor

Eighteen of 20 pilots and all 15 crewmen reported that the torso armor could be put on "moderately fast" or "very fast", with 19 of the pilots and 13 of the crewmen reporting this "easy" or "very easy" to do. Ease and speed of donning the armor appears adequate. Additional familiarity with the items and practice in their use can be expected to reduce the number and degree of difficulties. Speed of doffing was not rated because of the rapid action of the quick-release mechanism, but ease of doffing was. Only two pilots and one crewman reported even moderate difficulty in taking off this armor.

Comments

Pilots. The four comments in Table IX concerning improvement of the quick-release feature indicate its relative importance and pilots' dissatisfaction with the present design. The three requests for increased protection and three for reduced restriction and weight indicate that about as many pilots felt they were overburdened as felt they were under-protected.

Table VII: Distribution of pilots' ratings for dimensions of torso front protective units

Properly Fitted Size	Length			Chest Width			Waist Width			Curvature		
	Too Short	About Right	Too Long	Too Narrow	About Right	Too Wide	Too Narrow	About Right	Too Wide	Too Little	About Right	Too Much
Long	2	4	1	3	4	-	1	5	1	-	7	-
Regular	3	5	-	2	6	-	-	7	1	-	8	-
Short	-	1	-	-	1	-	-	1	-	-	1	-
Total	5	10	1	5	11	0	1	13	2	0	16	0

Table VIII: Distribution of crewmen's ratings for properly fitted torso front and back protective units

Properly Fitted Size	Front Length			Chest Width			Front Waist Width			Chest Curvature		
	Too Short	About Right	Too Long	Too Narrow	About Right	Too Wide	Too Narrow	About Right	Too Wide	Too Little	About Right	Too Much
Regular	-	3	1	-	3	1	-	4	-	-	4	-
Short	-	-	-	-	-	-	-	-	-	-	-	-
Total	0	3	1	0	3	1	0	4	0	0	4	0

Properly Fitted Size	Back Length			Shoulder Width			Back Waist Width			Back Curvature		
	Too Short	About Right	Too Long	Too Narrow	About Right	Too Wide	Too Narrow	About Right	Too Wide	Too Little	About Right	Too Much
Regular	-	6	-	-	6	-	1	5	-	2	4	-
Short	1	-	-	-	1	-	-	1	-	-	-	1
Total	1	6	0	0	7	0	1	6	0	2	4	1

When interpreted in the light of the generally satisfactory performance and fit data, these conflicting comments indicate that the TFPA design approached the fine line between overburdening the pilot with too much protection and providing him with insufficient armor coverage.

Crewmen. Four of the six comments from crewmen in Table IX concerned providing increased protection at the waist. If this should be accomplished by enlarging both the front and back armored components, the pilots would not be able to wear the same TFPA unit as the crewmen. As pilots indicated a possible need for reducing the waist coverage, the only feasible means for increasing the side coverage for the crewman appears to be widening the back armor at the waist and providing more wrap-around at the sides.

Table IX: Content of all comments and suggestions pertaining to the torso protective units.

Comment/suggestion	Frequency
a. Pilots (torso front only):	
1. Unit requires quick-release snaps on both shoulders.	2
2. Torso armor should be flexible.	2
3. Unit requires greater coverage at sides.	2
4. Unit requires a single motion quick-release.	2
5. Unit is very good at present.	2
6. Armor should be more adjustable.	1
7. Armor should be lighter in weight.	1
8. Armor should have a better pouch for survival kits.	1
9. Shoulder snaps are difficult to fasten while wearing armor.	1
10. More body coverage is required.	1
11. Corners of waist stick out too far.	1
b. Crewmen (torso front and back):	
1. Unit requires greater coverage at sides.	3
2. Unit is very good at present.	2
3. Lower back should be widened.	1

Best-liked Features.

Pilots. Table X shows that these were the relatively light weight of the TFPA, its comfort features and the amount of mobility and protection afforded. In addition, the comments on the comfort of the chest curvature, when taken together with the unanimously satisfactory ratings for this characteristic, indicated that this chest curvature should be preserved in all future designs of torso armor unless valid indications to the contrary are received.

Crewmen. Table X shows that the features of the TFPA and TBPA best-liked by crewmen paralleled those of the pilots with regard to fit and comfort characteristics. One crewman commented favorable on the weight distribution. The two surprising remarks concerning the "light weight" of the TFPA and TBPA combined were interpreted as meaning the "relatively light weight for the protection afforded". This interpretation appears to be a more realistic appraisal of a system which weighed 25 pounds in size Short and 35 pounds in size Long.

Conclusions Concerning Torso Protective Armor

1. Of 16 pilots and 7 crewmen who were properly fitted, no subject experienced major restriction while only two pilots and one crewman experienced minor restriction to body movement. These restrictions did not interfere with successful performance of their duties.

2. Three of the 7 misfitted crewmen (but none of four misfitted pilots) reported restriction, two of them being unable to properly perform certain duties.

3. The TFPA was generally acceptable to pilots in its present configuration. It was rated as fitting well and having a moderate degree of comfort for its weight and bulk. The length, chest width, and curvature of the TFPA appeared adequate.

4. The quick-release feature of the TFPA is important to pilots, and some would like the feature to be even faster.

5. The TFPA was acceptable to crewmen, whose comments showed it to be generally well-fitting, properly curved, and comfortable.

6. In its present configuration, the TBPA appears to be only marginally acceptable to crewmen. Changes in its shape are needed.

Table X: Summary of best-liked torso protective unit features.

Feature	Frequency
a. Pilots (torso front only)	
1. The light weight of the unit.	7
2. The comfortable chest curvature.	6
3. The general freedom of movement.	5
4. The arm cut-outs allowing free arm movement.	5
5. The generally comfortable fit.	4
6. The .30 caliber AP protection.	4
7. The unit is cooler than the flak vest.	2
8. Ease of donning and doffing.	1
9. The quick-release features.	1
b. Crewmen (torso front and back)	
1. The general freedom of movement.	3
2. The generally comfortable fit.	3
3. The generally comfortable curvature.	2
4. The unit is comfortable (unspecified).	2
5. The light weight of the unit.	2
6. The protection offered.	1
7. The good weight distribution.	1
8. Ease of donning and doffing.	1
9. The complete back coverage.	1
10. The shape of front allowing free arm movement.	1
11. The unit is cooler than the flak vest.	1

Recommendations

Torso Front Protective Armor.

1. The carrier portion of the TFPA should be redesigned with firmer shoulder padding and increased adjustment to position the armored plate higher on the body.

2. The width of the armored portion at waist level should be reduced one-half inch in sizes Regular and Long.

3. The present chest width, length and curvature should be preserved in future designs.

4. The quick-release feature should be improved to provide easier and faster operation and complete separation of the front and back portions by means of s single body action.

Torso Back Protective Armor.

1. The back curvature of the TBPA should be increased for size Regular and reduced for size Short.

2. For all sizes, the back width at the waist should be increased one-half inch and the side portions extended as far forward as the TFPA, to increase protection for the sides of the torso.

3. The present length and shoulder width should be preserved in future designs.

4. The armored panel should be suspended higher on the shoulder straps to prevent interference with the body in the lower back area.

STUDY III: EVALUATION OF SEAT/GROIN PROTECTIVE UNIT

Description of Item and Concept of Use

As evaluated, the seat/groin protective unit consisted of a 16½ by 12 inch flat ceramic/glass reinforced plastic composite armored plate, approximately elliptical in shape. A seven inch armored projection extended upward from the center of one of the longer edges to serve as a groin protector. The seat portion of the unit was cushioned by a one-half inch thick pad of

semirigid elastic foam bonded to the top surface. The entire unit weighed 13 pounds and was covered with a single layer of woven ballistic nylon fabric, (MIL-C-12369 - Cloth, Nylon, Ballistic for Armor). The seat/groin protector was rested on top of the troop seat in the cargo compartment where the crew chief or gunner normally sits, thereby providing the occupant with armor protection for his buttocks and trotch region (See Figure 4).

Crewmen Who Used the Protective Unit.

Four crew chiefs and eight door gunners, ranging in age, height, weight, and chest circumference as shown in Table XI, used the seat/groin protective unit for approximately one-half hour on a live fire mission against actual or simulated targets. All crewmen were a subsample of those who evaluated the Torso Protective Armor and were wearing TFPA and TBPA during the seat/groin unit evaluation.

Table XI: Summary statistics for age and body dimensions of crewmen who evaluated the seat/groin protective unit.

Dimension	Range	Mean	S.D.	N
Age (years)	19-49	29.4	9.2	12
Weight (pounds)	130-190	165.3	18.0	12
Height (inches)	65-72	69.0	2.3	12
Chest circumference (inches)	34-40	37.4	1.8	8

Results

Restriction to Movement.

Two crew chiefs and two door gunners of the twelve crewmen evaluating the item reported that they had suffered major restriction to body movement while attempting to fire at targets. The principal restriction was to the crewman's ability to track his target by pivoting in his seat. As the seat/groin unit was rested on top of the existing troop seat, frictional forces prevented the unit from "following along" as the crewman attempted to pivot. The groin protector added to the restriction and caused discomfort by providing a barrier to leg movement which chafed the inner surfaces of the thighs. Inspection of

Fig. 4. Seat/Groin Protective Unit

the body size ranges showed no meaningful differences between those crewmen who were restricted and those who were not. The reason for the lack of restriction of some crewmen could not be determined. It was suspected that those crewmen who were not restricted were able to successfully compensate for the seat unit's lack of movement by increasing their upper body rotation.

Adequacy of Seat/Groin Unit Dimensions.

Most of the crewmen rated each dimension of the unit as "about right"; all 12 so rated the curvature of the crotch protector. One crewmen rated seat width as "too small", another crewman so rated seat depth and a third crewman rated both these dimensions as "too small". Only one of the four crewmen suffering restriction to movement indicated dissatisfaction with any of the seat unit dimensions; he rated the height of the crotch protector as "too small".

Estimates of Length of Time Seat/Groin Unit Could be Used.

Of the 11 subjects responding, six indicated no limit, four indicated two hours or more and one indicated no more than one-half hour. The unit in its present form appears to be usable by most crewmen for at least a two hour period between refueling stops. Improvements in swiveling action would probably increase the length of time it could be used.

Comments.

Five comments were received to the effect that the sitting surface required more padding and four suggestions were made that the unit should attach to or swivel with the crewman. In addition, there were two comments that the crotch protector be padded and one that it be hinged.

Best-liked Features.

Five crewmen mentioned both seat and crotch protection, three indicated only crotch protection, one liked the height of the crotch protector and three did not respond. The individual who liked the height of the crotch protector suggested that it be used as a rest for the machine-gun butt.

Conclusions Concerning the Seat/Groin Protective Unit

1. The unit is useful and acceptable in its present configuration, but could be improved significantly.

2. From the lack of comment to the contrary, the seat/groin unit appeared to be compatible with the following tasks: wearing upper body protective armor, loading, unloading and firing the machine gun, attaching and releasing the crewman's safety restraint, and performing routine in-flight tasks not associated with weapon operation.

3. The small number of critical comments strongly suggests a lack of severe problems. More extensive evaluation in terms of flight time or sample size might have revealed additional difficulties, however.

Recommendations for Improving the Seat/Groin Protective Unit

1. Provide the unit with a swiveling action to better permit the crewman to track targets.

2. Increase the side-to-side width and the front-to-rear depth of the sitting surface to insure adequate accommodation of the largest percentile crewman deemed feasible.

3. Provide the sitting surface with at least one inch (but no more than three inches) of firm but comfortable cushioning to reduce discomfort and fatigue due to the lack of adequate blood circulation in the buttocks.

4. Provide the edges of the crotch protector with comfortable padding.

5. Provide a hinged joint between the crotch protector and the sitting surface to eliminate a possible safety hazard and increase ease of entry into and exit from the aircraft.

6. Investigate the need for modifying the outline of the crotch protector to conform adequately to the shape of the thigh. The present study indicated that such modification may be required.

7. Apply the curvature, height and width of the present crotch protector to future designs, as these dimensions seem to be adequate.

STUDY IV: ASSESSMENT OF POST-TEST ATTITUDES TOWARD AIRCREW ARMOR PROTECTION

Procedure

After completing the Background Information and Individual Item Questionnaires and before completing the Final Questionnaire, each pilot used the TFPA and each crewman used both the TFPA and TBPA in a UH-1 B or D model helicopter for approximately one-half hour on a live fire mission against actual or simulated targets. Final Questionnaire results were compared with Background Information Questionnaire results from Study I in order to determine changes in attitudes resulting from use of the armor.

Results

Post-test Acceptability of Armor for Combat Flights.

In spite of the additional experience gained by evaluating the tested prototypes and a slight difference in wording, the results of Item 1 of the Final Questionnaire were essentially the same as those for Item 28 of the Background Information Questionnaire. The only meaningful difference was that after using the armor, two gunners checked "d. The interference with operating efficiency outweighs the value of the protection furnished by body armor".

Armor Components Desired for Flight Missions.

Twenty pilots and 15 crewmen completed Item 2 of the Final Questionnaire. The instructions were: "The types of flight missions are listed at the left and the four armor components are listed in the columns at the right. Opposite each type of flight mission check each of the armor components you would like to wear on that type of mission". Table XII summarizes the results. The pilots desired torso front protective armor for nearly all flights, and seat protective armor about 40% of the time. Only 17% of pilots wanted to use the TBPA and only 6% desired to use the Leg Protective Armor. Although a somewhat smaller proportion of gunners and crew chiefs than pilots desired to use TFPA, a much larger proportion of them wished to use Seat Protective, Torso Back, and Leg Protective Armor. The totals and ranks at the right of Table XII indicate the relative desire for armor protection on the ten kinds of missions which are listed.

Utilization and Issue of Armor.

Items 3-7 of the Final Questionnaire furnished supplemental information concerning when and how the armor should be used:

1. The results of Item 3 indicate that 28 of the 35 pilots and gunners (80%) would put on chest or chest and back torso protective armor on the ground before entering the aircraft, five (14%) would put on the armor in the aircraft before take-off and two gunners (6) would put it on in flight prior to expected enemy contact.

2. Item 4 indicates that 9 of 34 (26%) would don the leg armor on the ground before entering the aircraft, (29%) would put it on in the aircraft before take-off, (6%) just after take-off, (9%) in flight prior to expected enemy contact, and (29%) (mostly pilots) answered "f. I will never wear leg armor on any mission".

3. Item 5 indicates that 26 of 35 pilots and crewmen (74%) would never or hardly ever wear TFPA or TBPA when performing ground duties, (17%) would wear it most of the time and (9%) would wear it about a quarter of the time.

4. Item 6 indicates that when not wearing the armor, (49%) would stow it in the aircraft, (26%) in the ready room, (17%) in the billets, and (9%) in some other location.

5. Results for Item 7 indicate that 13 of 35 (37%) think the armor should be issued as "d. Aircraft on board equipment (like the fire extinguishers), 34% favor "a. Individual issue (like your flight helmet), 26% favor "b. Company issue (like your individual weapon)" and 3% favored "c. TA-21 issue through RSO (like your field pack)".

Conclusions Regarding Post-test Attitudes

1. The results of Items 1 and 2 of the Final Questionnaire, when taken together, form a strong endorsement of the need for torso protective armor by the pilots and crewmen who used it.

2. Results of Item 1 of the Final Questionnaire agree with the pre-test responses to Item 28 of the Background Information Questionnaire. This indicates that attitudes toward the need for armor were only slightly affected by this experience with armor.

3. Pilots want TFPA for nearly all types of combat flight missions.

4. Of 15 crewmen, 87% want TFPA and 73% also want Torso Back and Seat/Groin Protective Armor.

GENERAL CONCLUSIONS

1. Armor used prior to this test was not favorably regarded. The median rating which the participating pilots and crewmen awarded the armor that was in use in RVN at the beginning of the study was only "It is fair".

2. In contrast, the results of Item 28 of the Background Information Questionnaire and Items 1 and 2 of the Final Questionnaire indicated that crew members who used body armor in this test had a strong desire to wear it on a wide variety of combat flight missions.

3. Pilots and crewmen differed somewhat in their rankings of various body areas with respect to their need for protection, but agreed that the legs were of lesser importance than the head, neck, torso or groin.

4. Pilots want Torso Front Protective Armor for nearly all combat flight missions and gunners and crew chiefs want it for most missions.

5. The quick-release feature was considered important for TFPA and should be improved to provide easier operation.

6. The suspension of the TFPA should be improved.

7. Almost 75% of gunners and crew chiefs want Torso Back Protective Armor even though its present configuration appears to be only marginally acceptable to them. Changes in both contour and shape are needed.

8. Almost 75% of the gunners and crew chiefs would want to use the seat/groin protective unit on a variety of combat flight missions.

9. It is believed that the acceptability of the seat/groin unit to crewmen would be materially improved by incorporating a swiveling action into its design, by minor changes in its shape, and by improving its padding.

10. About one-fourth of the gunners and crew chiefs desired leg armor. However, the prototype design for test purposes should be improved to make it more quickly adjustable to accommodate varying leg lengths.

Table XII: Armor Components Desired for Missions of Various Types

Type of Mission	Torso Front		Torso Back		Leg Protector		Seat/Groin Protector		All Four Type	
	Pilots	G&CC	Pilots	G&CC	Pilots	G&CC	Pilots	G&CC	Pilots Total	G&CC Rank
a. Troop transport to contact	20	13	3	11	2	4	11	12	76	3
b. Troop transport, Contact possible but not expected	20	10	4	8	1	2	8	10	63	8
c. Armed escort	20	15	5	11	2	6	10	12	81	2
d. Visual reconnaisance and target destruction (Seek and Kill)	20	14	5	13	2	10	8	13	85	1
e. Tactical medical evacuation	19	14	4	12	2	2	8	12	73	4
f. Downed aircraft recovery	19	13	4	13	2	2	7	9	69	5
g. Air Observation Post (For Forward Observer)	18	13	2	11	0	5	7	10	66	7
h. Night reconnaisance	19	14	2	12	0	3	6	11	67	6
i. Psychological warfare	16	11	3	9	0	3	8	10	60	9½
j. Aerial resupply	19	12	1	9	0	1	7	11	60	9½
Totals	190	129	33	109	11	38	80	110	700	
% of missions	95%	86%	16.5%	73%	5.5%	25.3%	40%	73.3%		

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MAJ William T. Effler, USARV

Aircrew Armor Evaluations

Instructions for experimenter

Opening remarks to subjects

To include:

1. The present study is an evaluation of our newest types of protective armor for pilots, co-pilots, crew chiefs and gunners. In order to make our latest developments in aircrew armor even better suited for the job they have to do, combat aircrews have to fly with them on and tell us what works and what doesn't work.

2. This is your part in the Research & Development effort. We need information from you. In order to get this information, we have designed a series of questionnaires for you to complete.

   a. The first questionnaire will give us background information on you.

   b. The second type of questionnaire concerns the armor items we will ask you to fly with.

   c. The last questionnaire gives us information after you have flown with all the items.

3. These questionnaires will give us the information we need <u>if they are filled out carefully</u>. Please give us your opinions, no matter what they are. You can't hurt our feelings.

4. All information is strictly between us. <u>No one but the experimenters</u> will see the questionnaires. Names are used to match opinions with background data.

5. I'll answer any questions you may have now.

Instructions for administering questionnaire #1

This questionnaire concerns background information vital to interpreting the test results. Fill in the blanks or circle the correct answer, as applicable. If you don't understand a question, please raise your hand and I will come to you. Be as complete and accurate as possible. There is no time limit. Please begin.

Give questionnaire #1.

At end of session - Any further questions?

Start fitting for item evaluations.

Aircrew Body Armor Design Evaluation

Interview Recording Sheet IRS-1

Date_____ Name_____

Height(w/o shoes)_____Weight(w/o clothing)_____Chest cir_____Waist cir_____

Item Worn_____Fit O.K._____Fit not O.K._____

Phase I: Crewman at duty station, aircraft on ground.

a. Request crewman to simulate performing his major mission. Question him as follows:

1. "WERE THERE ANY RESTRICTIONS TO, OR INTERFERENCES WITH, MOVEMENT?"

(a) YES (b) NO

2. "WHERE ON YOU DID THESE RESTRICTIONS OR INTERFERENCES OCCUR?"_____

_____

_____

3. "WHAT PART OF THE ITEM INTERFERED?" _____

_____

_____

4. "WHAT WAS THE RESULT OF THE INTERFERENCE?" _____

_____

_____

5. "HOW SEVERE WAS THE INTERFERENCE?" _____

_____

_____

6. "WHAT BODY MOVEMENTS WERE YOU MAKING?" _____

_____

_____

b. Repeat Phase I with next crewman until entire crew covered.

Phase II: Let entire crew fly a simulated mission; question each subject individually as follows:

a. "WHAT OTHER ITEMS OF THIS TYPE HAVE YOU WORN BEFORE?" (List them below: and ask them to rank their preferences (1 = most preferred))

	Type of item	Rank
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____

AMXRE Form 3470
3 February 1966

b. "WHY DID YOU CHOOSE YOUR FIRST PREFERENCE?"_____

_____

_____

Phase III: Let subject fill out the appropriate questionnaire #2 for this item.

MARK THE QUESTIONNAIRE "SPECIAL" before you give it to the man.
Attach to this sheet upon its return.

Aircrew Body Armor Design Evaluation

1. Background information questionnaire

Date: _____

Information concerning the respondent

1. NAME:_____ 2. RANK:_____ 3. AGE:_____

4. HEIGHT(without shoes):_____in. 5. WEIGHT(without clothing):_____pounds

6. MOS:_____ 7. NAME OF MOS:_____

8. ORGANIZATION:_____

9. LOCATION:_____

10. NUMBER OF MONTHS stationed in this Combat Zone:_____

11. LENGTH OF SERVICE in years and months:_____

12. LENGTH OF FLYING EXPERIENCE:_____

13. APPROXIMATE NUMBER OF FLIGHT HOURS:_____

14. YEAR OF BIRTH:_____

15. AGE AT LAST BIRTHDAY:_____

16. EDUCATION: I have finished: (circle correct answer)

a. Some Grade School
b. Grade School
c. Some High School
d. High School
e. Some College
f. College

17. The total number of MONTHS I have been IN COMBAT is:_____months.

18. The approximate NUMBER of COMBAT MISSIONS I have flown is:_____missions.

19. The approximate NUMBER of COMBAT HOURS I have flown is:_____hours.

20. List Battle Stars and/or other combat awards received:_____

_____

AMXRE OT Form 347A
3 February 1966

21. PAST EXPERIENCE WEARING ARMOR (Flight helmets and steel helmets are not included). Circle one or more answers and fill in the other information requested.

a. I have never worn any body armor before today.

b. I have worn body armor during training flights.

(Describe type of armor worn): (22) _____

c. I have worn body armor during combat flights.

(Approximate number of combat hours flown while wearing armor)

(23) _____

(Describe type of armor worn): (24) _____

d. I have been hit while wearing armor on a combat flight.

(Describe type of armor worn and results of hit): (25) _____

_____

26. ASSIGNED POSITION IN AIRCRAFT: _____

27. ASSIGNED AIRCRAFT TYPE: _____

28. In general, how do you feel about wearing body armor on combat flights?

a. I like the protection and always want to wear the best armor available.

b. Body armor protection is desireble even though it is heavy, gets in the way and makes it hard to do your job.

c. The advantages and disadvantages of wearing body armor are about equal.

d. The interference with operating efficiency outweighs the value of the protection furnished by body armor.

e. Body armor is so heavy and clumsy that one is safer without it.

f. I have no opinion at all.

29. WHAT BODY AREAS DO YOU WANT PROTECTED MOST? (Number the area most important to protect 1, the next most important 2 and so on. In addition, draw a line through every area which you think needs no protection or where protective equipment would be a disadvantage.)

a. Head and neck _____.

b. Chest _____.

c. Abdomen (belly) _____.

d. Groin (crotch) _____.

e. Upper legs _____.

f. Lower legs _____.

30. What do you think of the body armor which is presently in use?

    a. It does a good job just as it is.

    b. It is good although some improvements are needed.

    c. It is fair.

    d. It is poor.

    e. One would be safer without armor.

    f. I have no opinion.

31. What are the main good points and bad points in the presently used body armor? Describe. _____

_____

_____

_____

32. State briefly how you personally feel about using body armor on combat flights: _____

_____

_____

_____

AMXRE ST Form 347A
3 February 1956

2. INDIVIDUAL ITEM QUESTIONNAIRE

A. TORSO FRONT ARMOR

NAME _____ DATE _____

1. Did you notice any restrictions to, or interferences with, movement which were related to this armor?

   a. Yes b. No

If your answer to Question 1 was "No", omit questions 2, 3, 4 and 5.

2. Indicate the location of each restriction or interference. _____

3. What was the nature of each restriction or interference? _____

4. How severe was each restriction or interference? _____

5. What job were you doing and what body movements were you making at the time of each interference or restriction? _____

INSTRUCTIONS: for each of the following questions, circle the answer which best describes your feelings. Make any comments you desire in the spaces provided.

6. How long do you think you can wear the torso front armor and perform your job satisfactorily?

   a. 1/2 hour b. 1 hour c. 2 hours d. 4 hours e. 6 hours or more

7. What do you think of the length of the torso front armor?

   a. Too long.

   b. Too short.

   c. About right.

   Comments on length: _____

   _____

8. What do you think of the chest width of the torso front armor?

   a. Too wide.

   b. Too narrow.

   c. About right.

   Comments on chest width: _____

   _____

9. What do you think of the width of the torso front armor at your waist?

   a. Too wide.

   b. Too narrow.

   c. About right.

   Comments on width at waist: _____

   _____

10. What do you think of the curvature of the torso front armor?

    a. Curved too much.

    b. Curved too little.

    c. Curvature about right.

    Comments on curvature: _____

    _____

11. How rapidly can you put on the torso front armor?

    a. Very fast.

    b. Moderately fast.

    c. Slowly.

    d. Very slowly.

    Comments on speed of putting on the torso front armor: _____

    _____

12. How difficult is it to put on the torso front armor?

    a. Very difficult.

    b. Moderately difficult.

    c. Easy.

    d. Very easy.

    Comments on difficulty in putting on the torso front armor: _____

    _____

13. How difficult is it to take off this armor?

    a. Very difficult.

    b. Moderately difficult.

    c. Easy.

    d. Very easy.

    Comments on difficulty of taking off thie armor: _____

    _____

14. Suggest ways in which you think the torso front armor could be improved: ____

    _____

    _____

    _____

15. What features of the torso front armor do you especially like? _____

    _____

    _____

    _____

2. INDIVIDUAL ITEM QUESTIONNAIRE

B. TORSO BACK ARMOR(worn with TORSO FRONT ARMOR)

NAME_____ DATE_____

1. Did you notice any restrictions to, or interferences with, movement which were related to this armor?

   a. Yes b. No

If your answer to Question 1 was "No", omit questions 2, 3, 4 and 5.

2. Indicate the location of each restriction or interference. _____

3. What was the nature of each restriction or interference? _____

4. How severe was each restriction or interference? _____

5. What job were you doing and what body movements were you making at the time of each interference or restriction? _____

INSTRUCTIONS: for each of the following questions, circle the answer which best describes your feelings. Make any comments you desire in the spaces provided.

6. How long do you think you can wear the torso back armor and perform your job satisfactorily?

   a. 1/2 hour b. 1 hour c. 2 hours d. 4 hours e. 6 hours or more

AMXRE OT Form 3-7C
3 February 1966

7. What do you think of the length of the torso back armor?

   a. Too long.

   b. Too short.

   c. About right.

   Comments on length: _____

   _____

8. What do you think of the width across the shoulders of the torso back armor?

   a. Too wide.

   b. Too narrow.

   c. About right.

   Comments on width across shoulders: _____

   _____

9. What do you think of the width across the lower back?

   a. Too wide.

   b. Too narrow.

   c. About right.

   Comments on width across lower back: _____

   _____

10. What do you think of the curvature of the torso back armor?

   a. Curved too much.

   b. Curved too little.

   c. Curvature about right.

   Comments on curvature: _____

   _____

11. How rapidly can you put on the combined back and front torso armor?

   a. Very fast.

   b. Moderately fast.

   c. Slowly.

   d. Very slowly.

   Comments on speed of putting on the combined back and front torso armor: _____

   _____

12. How difficult is it to put on the combined back and front torso armor?

    a. Very difficult.

    b. Moderately difficult.

    c. Easy.

    d. Very easy.

    Comments on difficulty in putting on the combined back and front torso armor:

    _____

    _____

13. How difficult is it to take off the combined back and front torso armor?

    a. Very difficult.

    b. Moderately difficult.

    c. Easy.

    d. Very easy.

    Comments on difficulty of taking off this armor: _____

    _____

14. Suggest ways in which you think the torso back armor could be improved: _____

    _____

    _____

    _____

15. What features of the torso back armor do you especially like? _____

    _____

    _____

    _____

2. INDIVIDUAL ITEM QUESTIONNAIRE

C. LEG PROTECTOR

NAME _____ DATE _____

1. Did you notice any restrictions to, or interferences with, movement which were related to this armor?

   a. Yes b. No

If your answer to Question 1 was "No", omit questions 2, 3, 4 and 5.

2. Indicate the location of each restriction or interference. _____

3. What was the nature of each restriction or interference? _____

4. How severe was each restriction or interference? _____

5. What job were you doing and what body movements were you making at the time of each interference or restriction? _____

INSTRUCTIONS: for each of the following questions, circle the answer which best describes your feelings. Make any comments you desire in the spaces provided.

6. How long do you think you can wear the leg, front torso and back armor and perform your job satisfactorily?

   a. 1/2 hour b. 1 hour c. 2 hours d. 4 hours e. 6 hours or more

AAXRE 01 Form 347D
1 February 1984

7. What do you think of the length of the thigh armor?

   a. Too long.

   b. Too short.

   c. About right.

   Comments on length of thigh armor: _____

   _____

8. What do you think of the width of the thigh armor?

   a. Too wide (gets in way).

   b. Too narrow (tight).

   c. About right.

   Comments on width of thigh armor: _____

   _____

9. What do you think of the alignment of thigh protector with leg?

   a. Top points too far in towards crotch.

   b. Top points too far out.

   c. Top is aligned with leg.

   Comments on alignment: _____

   _____

10. Was the lower leg armor adjustable enough?

    a. Yes b. No

11. What do you think of the width of the leg armor at your knee joint?

    a. Too wide (gets in way).

    b. Too narrow (tight).

    c. About right.

    Comments on width at knee joint: _____

    _____

AMXRE OT Form 347D
3 February 1966

12. How is the width at your ankle?

    a. Too wide, fits too loosely.

    b. Too narrow, fits too tightly.

    c. About right.

Comments on width at ankle: _____

_____

13. How is the overall length of the leg armor when standing?

    a. Too long, upper edge too near crotch.

    b. Too short, not enough protection.

    c. Right length, neither too long nor too short.

Comments on overall length: _____

_____

14. How rapidly can you put on the leg armor?

    a. Very fast.

    b. Moderately fast.

    c. Slowly.

    d. Very slowly.

Comments on speed of putting on the leg armor: _____

_____

15. How difficult is it to put on the leg armor?

    a. Very difficult.

    b. Moderately difficult.

    c. Easy.

    d. Very easy.

Comments on difficulty in putting on the leg armor: _____

_____

16. How difficult is it to take off this armor?

    a. Very difficult.

    b. Moderately difficult.

    c. Easy.

    d. Very easy.

    Comments on difficulty of taking off this armor: _____

    _____

17. Suggest ways in which you think the leg armor could be improved: _____

    _____

    _____

    _____

18. What features of the leg armor do you especially like? _____

    _____

    _____

2. INDIVIDUAL ITEM QUESTIONNAIRE

D. SEAT PROTECTOR

NAME_____ DATE_____

1. Did you notice any restrictions to, or interference with, movement which were related to this item?

   a. Yes b. No

If your answer to Question 1 was "No", omit questions 2, 3, 4 and 5.

2. Indicate the location of each restriction or interference. _____

3. What was the nature of each restriction or interference? _____

4. How severe was each restriction or interference? _____

5. What job were you doing and what body movements were you making at the time of each interference or restriction? _____

INSTRUCTIONS: for each of the following questions, circle the answer which best describes your feelings. Make any comments you desire in the spaces provided.

6. How long do you think you can sit on the seat protector and perform your job satisfactorily?

   a. 1/2 hour b. 1 hour c. 2 hours d. 4 hours e. 6 hours f. no limit

AMXRE OT Form 317E
3 February 1986

7. What do you think of the front to rear depth of the seat protector?

   a. Too long.

   b. Too short.

   c. About right.

   Comments on depth: _____

   _____

8. What do you think of the side to side width of the seat protector?

   a. Too wide.

   b. Too narrow.

   c. About right.

   Comments on width: _____

   _____

9. What do you think of the height of the crotch protector portion of the seat protector?

   a. Too high.

   b. Too low.

   c. About right.

   Comments on height of crotch protector: _____

   _____

10. What do you think of the curvature of the crotch protector portion of the seat protector?

   a. Curved too much.

   b. Curved too little.

   c. Curvature about right.

   Comments on curvature: _____

   _____

11. Suggest ways in which you think the seat protector could be improved: _____

   _____

   _____

   _____

12. What features of the seat protector do you especially like? _____

   _____

   _____

   _____

AMXRE OT Form 347E
3 February 1966

3. Final questionnaire

NAME_____ DATE_____

1. In general, how do you now feel about wearing body armor on combat flights? (Circle one answer)

   a. I like the protection and always want to wear the best armor available.

   b. Body armor protection is desirable even though it is heavy, gets in the way and makes it hard to do your job.

   c. The advantages and disadvantages of wearing body armor seem to be about equal.

   d. The interference with operating efficiency outweighs the value of the protection furnished by body armor.

   e. Body armor is so heavy and clumsy that one is safer without it.

2. Ten types of flight missions are listed below at the left and the four armor components are listed in columns at the right. Opposite each type of flight mission check each of the armor components you would like to wear on that type of mission.

Type of Mission	Armor Components			
	Torso Front	Torso Back	Leg Protector	Seat Protector
a. Troop transport to contact	____	____	____	____
b. Troop transport, contact possible but not expected	____	____	____	____
c. Armed escort	____	____	____	____
d. Visual reconnaissance and target destruction (Seek and Kill)	____	____	____	____
e. Tactical medical evacuation	____	____	____	____
f. Downed aircraft recovery	____	____	____	____
g. Air Observation Post (for Forward Observer)	____	____	____	____
h. Night reconnaissance	____	____	____	____
i. Psychological warfare	____	____	____	____
j. Aerial resupply	____	____	____	____

3. If you are going to wear chest or chest and back armor on a mission, when will you put it on? (Circle one answer)

   a. on the ground, before entering the aircraft.

   b. in the aircraft before take-off.

   c. in the aircraft just after take-off.

   d. in flight prior to expected enemy contact.

   e. in flight after enemy contact.

   f. I will <u>never</u> wear chest or chest and back armor on any mission.

4. If you are going to wear leg armor on a mission, when will you put it on? (Circle one answer)

   a. on the ground before entering the aircraft.

   b. in the aircraft before take-off.

   c. in the aircraft just after take-off.

   d. in flight prior to expected enemy contact.

   e. in flight after enemy contact.

   f. I will <u>never</u> wear leg armor on any mission.

5. How much of the time do you expect to wear chest or chest and back armor when performing ground duties? (Circle one answer)

   a. Most of the time.

   b. About half of the time.

   c. About a quarter of the time.

   d. Hardly ever.

   e. Never.

6. Where will you stow your armor when you're not wearing it? (Circle one answer)

   a. In the aircraft.

   b. In the billets.

   c. In the ready room.

   d. Someplace else. (Specify):_____

7. How should the armor be issued? (Circle one answer)

   a. Individual issue (like your flight helmet)

   b. Company issue (like your individual weapon)

   c. TA-21 issue through RSO (like your field pack)

   d. Aircraft on-board equipment (like the fire extinguishers).

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13. ABSTRACT

Thirty five U. S. Army helicopter crew members evaluated the design features and acceptability of .30 caliber armor-piercing protective armor on practice or actual live-fire aerial missions in South Vietnam. Twenty pilots used Torso Front Protective Armor, and 15 crew chiefs and door gunners used Torso Front Protective Armor, Torso Back Protective Armor and Seat/Groin Protective Units. They rated the following variables: fit, comfort, interference with movement, suitability of outline and contour, acceptability of armor before and after experience with the latest items, desirability of particular items on particular missions and body areas requiring protection. In general, they evaluated the items as both desirable and acceptable and expressed a strong desire to wear body armor on a wide variety of flight missions. Responses indicated that the Torso Front Protective Armor requires only minor improvement, but the Torso Back Protective Armor requires changes in both outline and contour. The Seat/Groin Protective Unit requires improvement to help it swivel with the user.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Evaluation	8					
Design	8					
Acceptability	8					
Body armor	9		10			
Torso	0		0			
Seat armor	9		10			
Helicopters	4		9			
Flight crews	4		9			
Pilots (personnel)	4		9			
Armor piercing ammunition	4		4			
Protection			8			

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